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(71) Applicant
The British Hydromechanics Research Association
(Incorporated in the United Kingdom)
Cranfield, Bedford MK43 0AJ, United Kingdom

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(72) Inventors
Roger Arlindale Heron
Edward John Bloomfield

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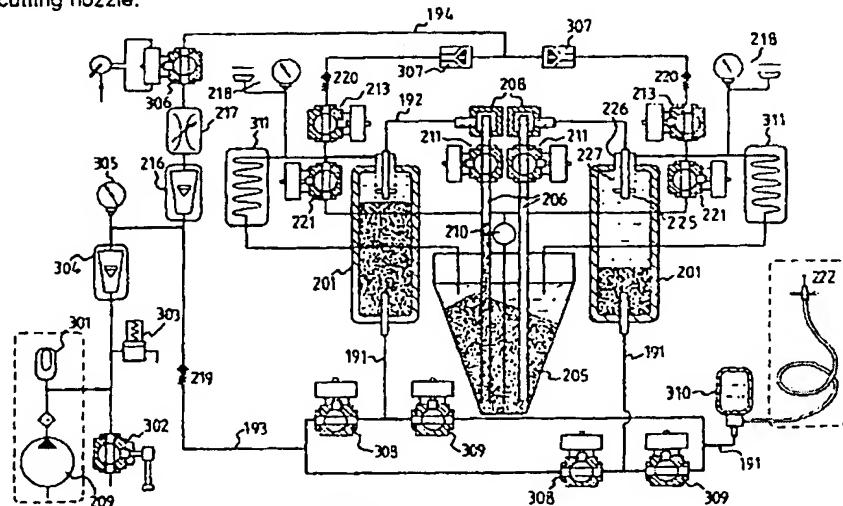
(74) Agent and/or Address for Service
Edward Evans & Co
Chancery House, 53-64 Chancery Lane,
London, WC2A 1SD, United Kingdom

(54) Feeding abrasive material

(57) An abrasive mixture is supplied from pressure vessels through conduits containing valves 309. Considerable wear is experienced by the valves when they are operated with abrasive material within them.

Wear is reduced in the valves 309 by providing valves 308 to flush the valves 309 before closing so that the abrasive material content is reduced preferably to zero. This avoids abrasive particles becoming caught between working parts of the valves 309 and causing undue wear.

When the conduits lead to a nozzle 222 from which the abrasive mixture is jetted for cutting purposes, the flushing of the valves 309 will cause a reduction in the concentration of abrasive mixture at the outlet in the normal circumstances. In order to avoid this reduction of concentration, the outlet of the valves 309 can be fed to the nozzle 222 through an abrasive mixture reservoir 310 which will smooth out variations in the abrasive mixture concentration and so maintain the efficiency of the jet from the cutting nozzle.



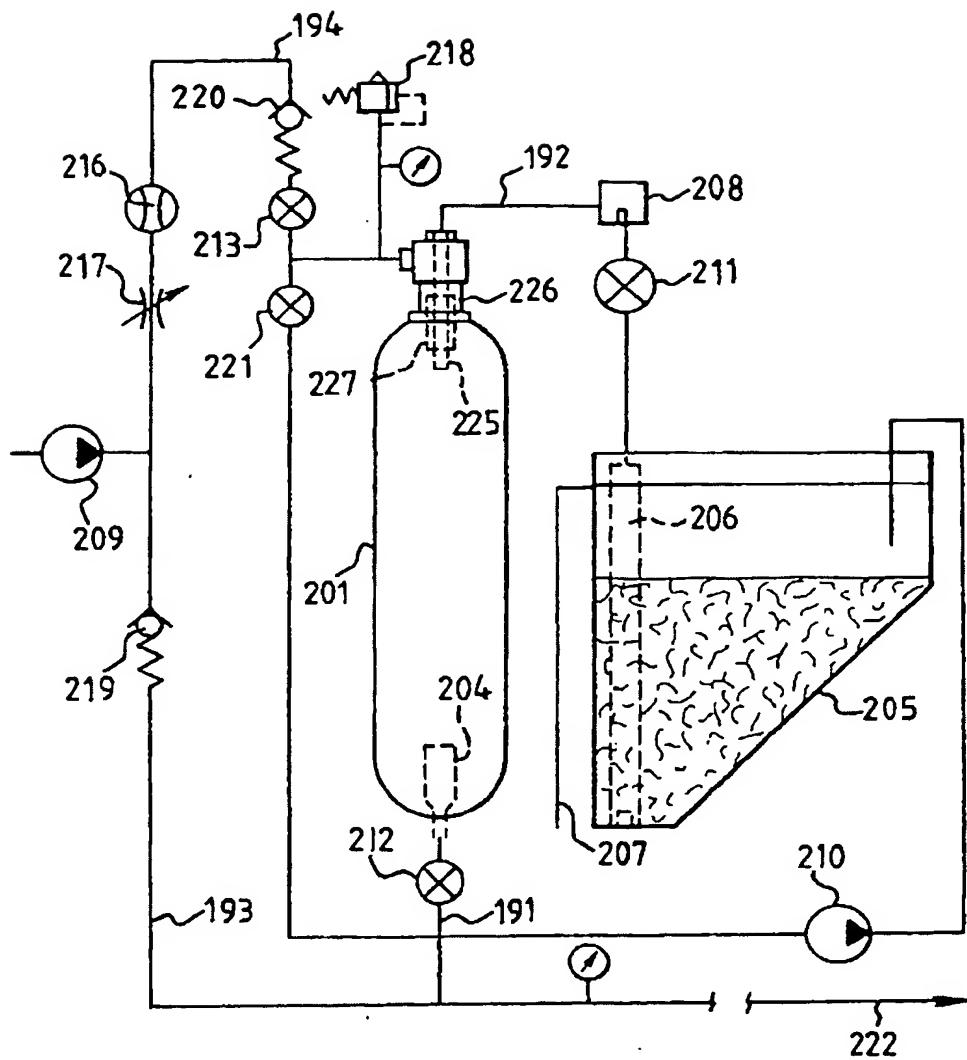


FIG.1

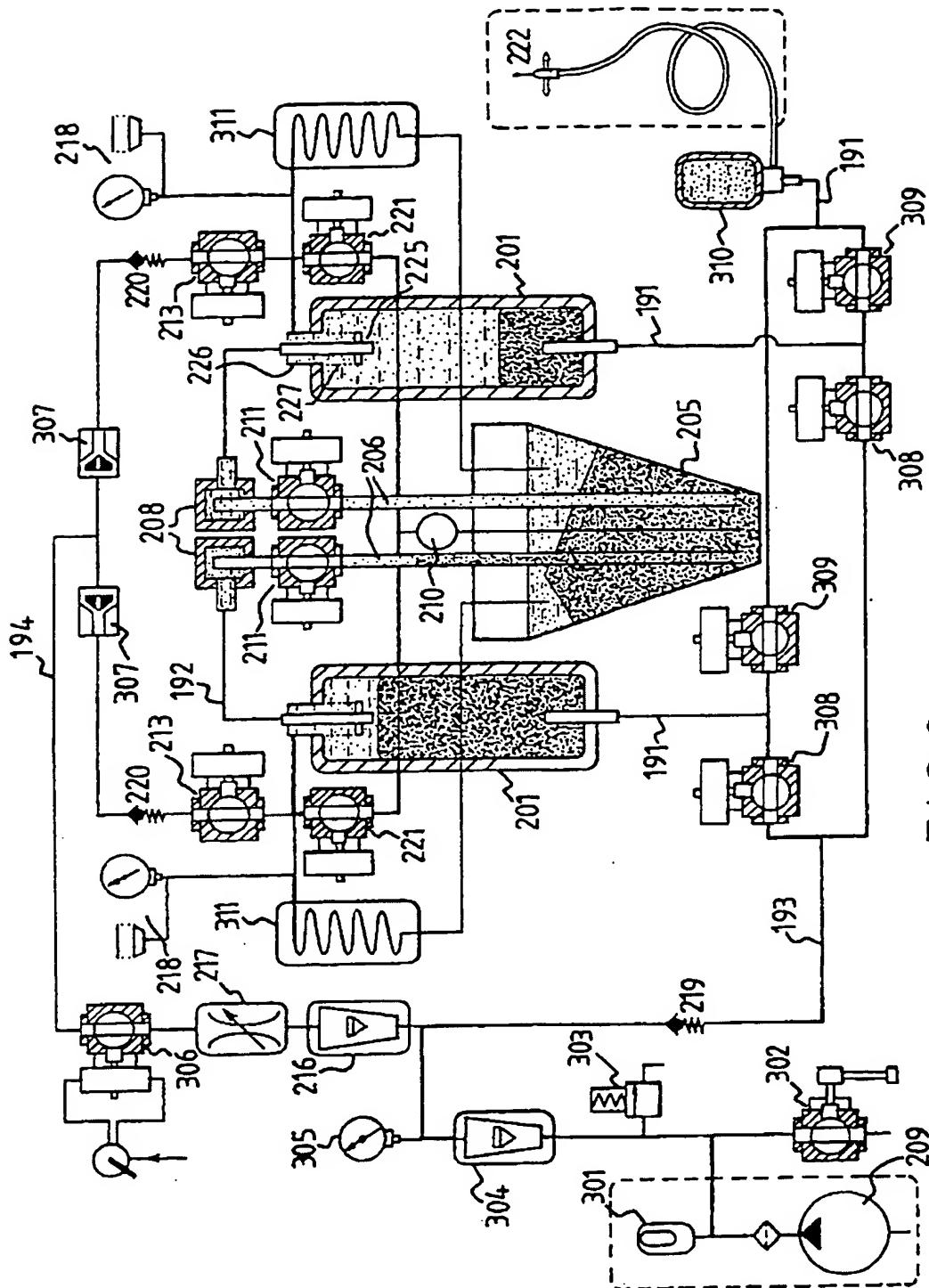
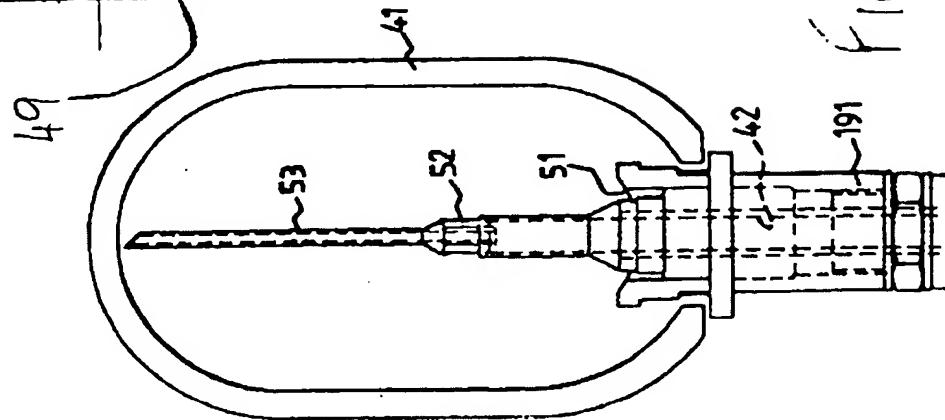
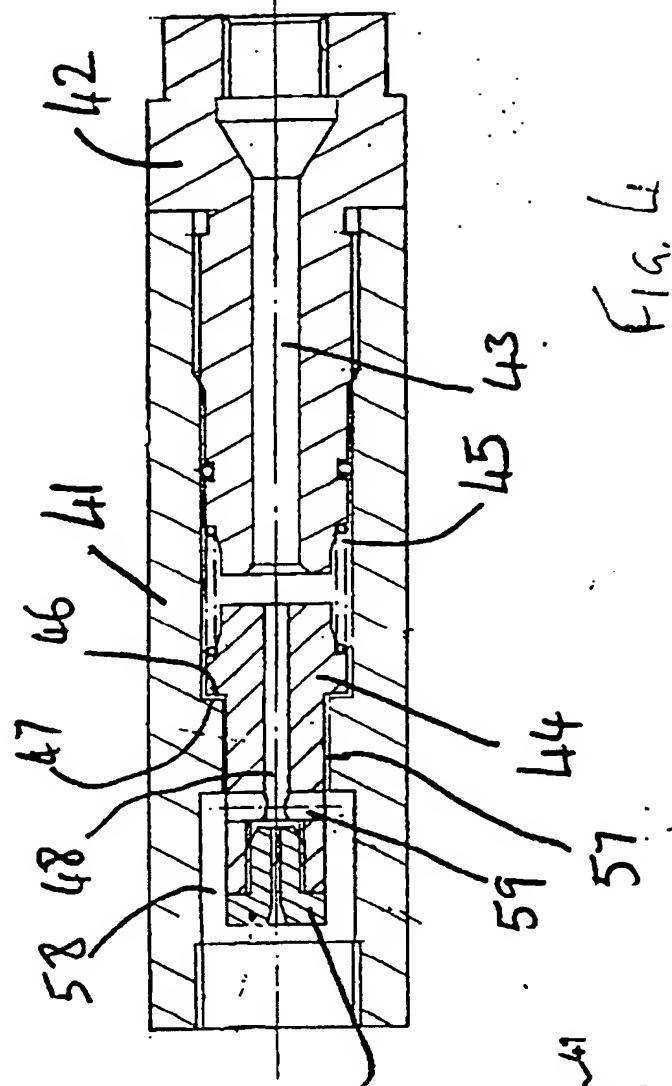


FIG. 2

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FEEDING ABRASIVE MATERIAL

This invention relates to the feeding of abrasive material in a carrier liquid and improves on the disclosure of WO 87/03290. In that disclosure two similar pressure vessels were interconnected to enable one vessel to discharge abrasive slurry whilst the other vessel was recharged in a cyclic arrangement to provide a continuous flow of abrasive slurry to a cutting nozzle. A number of problems had to be overcome to achieve a fully continuous and consistent slurry without large pressure surges in the system. To operate this system it was necessary to turn off the pump for a second or two to allow pressure in the system to decay before operating the valves, i.e. shutting the empty vessel and opening the full one. The method of clearing abrasive from the bottom valve was by allowing material to settle for a time. The discontinuity of pumping caused a discontinuity in cutting.

If the pump is not switched off when the valves on the vessel to be recharged are opened two problems manifest:

- i) The abrasive handling valves are difficult to operate in slurry against back pressure such as 350 bar due to the ingress of abrasive between the mating parts - putting strain on the actuator spindle and causing damage to the drive slot in the ball. Also the transient flow when the valve is opened picks up abrasive and creates a cutting effect which damages the sealing surfaces.
- ii) Because the vessel to be recharged is at low pressure the sudden irrush of water when the valve is opened causes a significant pressure drop in the system including the nozzle - reducing cutting performance.

Depending on the abrasive being used, the time to settle through the discharge valve is variable if all material is to clear the ball before closing and so to be sure a long time must be allowed.

According to one aspect of the present invention there is provided abrasive mixture supply apparatus comprising two pressure vessels interconnected to enable one vessel to discharge abrasive

slurry whilst the other vessel is being recharged in a cyclic arrangement to provide a continuous flow of abrasive slurry to a cutting nozzle (defined as the specified apparatus) with means for adjusting the pressure within a said pressure vessel. With this arrangement, excess pressures can be reduced so that flow valves can be more easily operated and surges of pressures or flow can be avoided. As an example, a continuous bleed from a said pressure vessel allows excess pressures to be bleed away over a short delay period, thus allowing valves to operate after this short delay period without difficulty.

According to another aspect of the invention there is provided the specified apparatus with means to flush abrasive material from a valve in the outlet of a said pressure vessel prior to closure. An abrasive mixing reservoir may be provided in said outlet to reduce the effect of the flushing on the concentration of abrasive material.

According to another aspect of the invention there is provided the specified apparatus with a flow fuse or limiting device in an inlet conduit to a said pressure vessel for carrier fluid, to limit flow and hence pressure surges in the system, particularly when being repressurised after recharging.

Other improvements will be seen from the following description of an embodiment of the invention with reference to the accompanying drawings in which:

25 Figure 1 is schematic diagram of apparatus described in WO 87/02290,

Figure 2 is a schematic diagram of a modification of the apparatus of Figure 1 according to the present invention,

Figure 3 is a detail of the mixing reservoir, and

30 Figure 4 is a longitudinal section through a flow fuse for use in the apparatus of Figure 2.

In the apparatus of Figure 1, abrasive material is fed, either in dry or in slurry form, into a hopper 205 filled with water extending to a maximum depth controlled by an overflow 207. Material from the base of the hopper can be drawn upwards through a vertical tube 206 leading to a trap 208 through a valve 211, the location of the valve being such that the volume of the conduit below the valve is greater than the volume of the conduit above the valve and below the trap by such a factor that when abrasive material of the operative concentration in the carrier fluid is present in the conduit above and below the valve and the flow stops, the abrasive material in the conduit will settle over a time to a maximum level which is below the level of the valve. This can be achieved by making the lower portion of the tube 206 of larger cross section than the portion above the valve. The valve in the rest state will then be in clear carrier fluid and the valve can operate without drawing abrasive material into its working parts. The minimum value of the factor depends on the concentration of abrasive material in the carrier liquid, but the apparatus can be designed with a factor suitable for most working concentrations.

20 Pressure vessel 201 has two co-axial conduits at its upper end and a trap type outlet at its lower end. The inner co-axial conduit 225 is connected through trap 208 and valve 211 to the tube 206. A high pressure water pump 209 feeds water in two branches; one branch leads through a variable flow restrictor 217, a flowmeter 216, a non-return valve 220 provided with a strainer 227 at the entry to the vessel 201. A junction between the valve 213 and the outer co-axial conduit 226 leads through a valve 221 to a suction pump 210 which feeds water into the top of the hopper 205. The pump 210 is capable of handling an inlet suction of 63cm Hg and 25 low concentration slurries, since some fine abrasive material will be passed by the strainer 227. A suitable pump is a pneumatic powered diaphragm pump. The other branch from the junction at the outlet of the pump 209 feeds through a non-return valve 219 to a junction from which one branch is connected through a valve 212 to 30 the outlet conduit 204 of the pressure vessel 201 and the other branch is connected to a discharge nozzle 222. The non-return valves 219 and 220 are chosen so that sufficient pressure

differential is created to pass a required flow through the pressure vessel 201, the remaining outlet of the pump by-passing the pressure vessel 201 through the valve 219. Relief valves 218 are provided for safety.

5 At the start of operations, the empty pressure vessel 201 is filled with water from the pump 209. After valve 213 has been closed and 221 opened, the suction pump 210 is energized to circulate water from conduit 226 at the top of the pressure vessel 201 through the valve 221 into the hopper 205 and from the base of 10 the hopper through the tube 206 back to conduit 225 of the vessel 201. Grit is supplied to the hopper and settles to the bottom. The pressure difference generated within the tube 206 and the locally increased liquid velocity fluidises abrasive material at the inlet to the tube 206 and a slurry of the water and the 15 particulate material contained in the hopper 205 is drawn into the pressure vessel 201 where the arrangement of components and the rate of flow are chosen so that the abrasive material settles out from the slurry while the water continues its circulation through conduit 226 to the pump 210. Eventually, the settled material will 20 reach the level of a strainer 227 at the entrance to the outer co-axial conduit 226 at the top of the container, stopping the flow when the strainer mesh becomes blocked. The abrasive material is chosen to be in a restricted band of particle sizes, so that there are plenty of voids in the material in the vessel 201 allowing 25 liquid to flow therethrough. The presence of a significant proportion of fines in such material reduces the flow of liquid through the settled material and furthermore such fines are not efficient when the abrasive material is entrained in a jet of carrier fluid and used for cutting purposes.

30 Grit is discharged from the pressure vessel 201 by applying water under pressure from the pump 209 through the valve 213 to the outer co-axial conduit 226, the valves 211 and 221 being closed and the valve 212 open. This flow of water in reverse to the previous flow clears grit from the strainer 227 and water passes 35 through the settled material to the base of the pressure vessel where the local flow pattern adjacent the outlet trap 204 fluidises

the material which passes through the trap 204 and the valve 212 to the nozzle 222. The discharge of the pressure vessel 201 can be stopped at any time by closing the valve 213, so that all the water from the pump 209 is then diverted through the non-return valve 219. Closure of valve 212 must be delayed after the flow of abrasive mixture has stopped, to allow abrasive material to settle into the conduit below the valve, leaving clear carrier fluid in the valve at the time it is closed to avoid damage.

The apparatus of Figure 2 adds some components to those of Figure 1. There is a pressure control device in the form of a bleed conduit 311 leading from the junction of the valves 213 and 221 back to the hopper 205 which provides a continuous bleed from the outlet 226. There is an accumulator 301 in the outlet from pump 209, together with a dump valve 302, a pressure relief valve 303, a flowmeter 304 and a pressure gauge 305. A valve 306 and a flow fuse 307 are located between the flow restrictor 217 (which in Figure 2 with respect to Figure 1 is reversed in position with the flowmeter 216) and the non-return valve 220. This valve 306 and others such as 213 and 221 are illustrated with rectangles alongside them, the rectangles denoting pneumatic control devices. Such devices are connected to a central controller (not shown) to control the operation of the system. The single valve 212 in the bottom outlet of the pressure vessel 201 in Figure 1 is replaced by valves 308 and 309 one on either side of the junction with the conduit from the non-return valve 219 along that conduit. A grit mixer 310 is located upstream of the nozzle 222.

In the apparatus of Figure 2, there are two vertical tubes 206 each leading through respective valves 211 and traps 208 to respective pressure vessels 201. Similarly the feed water from the flowmeter 216 divides into two branches, one for each pressure vessel 201, each branch having its own flow fuse 307, non-return valve 220, valve 213, valve 221, and relief valve 218, with a connection from the junction of the valves 213 and 220 to the outlet 226 of the respective vessel 201. There is a branch of the conduit downstream

of the non-return valve 219 for each vessel 201, each branch having its own valves 308 and 309, the branches joining up again upstream of the grit mixer 310.

The provision of the flow fuses 307 prevents excessive surges in the flow of fluid when the appropriate valve 213 is opened and a consequent pressure drop elsewhere, particularly in the pressure vessel being discharged. The flow fuse is shown in greater detail in Figure 4. A conduit body 41 has a retainer 42 mounted in one end, the retainer being formed with an axial passage 43 by which fluid flow may leave the fuse. A spool 44 is mounted within the body and biased away from the retainer by a spring 45, having a shoulder 46 which engages a corresponding shoulder 47 in the body to limit the movement under the bias of the spring. The shoulder 47 marks the beginning of a more restricted portion 57 of the bore of the body 41. The spool 44 has an axial passage 48 which is restricted at its inlet end by a jet defining device 49 which is screwed into the spool. Radial passages 59 connect the axial passage 48 of the spool to an enlarged portion 53 of the axial passage of the body 41 when the components are in the positions shown in Figure 4.

Fluid flows from the left to the right through the device of Figure 4, most of the fluid flowing around the outside of the jet defining device 49, through the radial passages 59 and the axial passages 43 and 48 of the components. When a surge in fluid flow occurs, the pressure on the end of the jet defining device 49 will cause the spool 44 to move against the bias of the spring 45 towards the retainer 42, thus moving the radial passages within the more restricted portion 57 of the conduit body so that they are closed off from the fluid flow inlet. Fluid can now only flow through the axial passage 48 of the jet defining device. When the pressure exerted by the fluid flow reduces, the components return to the positions illustrated. The fuse thus has the effect of limiting fluid flow to the maximum value at which the force exerted on the jet defining device 49 is balanced by the bias of the spring 45. The capacity of the fuse can be altered by substituting jet defining devices 49 of different axial passage bores.

When a pressure vessel 201 has been completely emptied, the abrasive material in the downstream valve 309 can be completely cleared by allowing clear water to flush it from the upstream valve 308 before both valves have closed, thus ensuring that the valve 5 only changes position when carrying clear carrier fluid, thereby reducing the wear in the valve. This can be done with more certainty in a shorter time than waiting for material to settle out from the valve, as in Figure 1. The occasional flushing of these valves does however reduce the concentration of abrasive material 10 flowing towards the nozzle and in order to maintain the concentration of abrasive material reasonably uniform, the grit mixer 310 is provided and is shown in greater detail in Figure 3. The mixer is essentially a reservoir of abrasive material through which the output of the valves 309 is passed. The material enters 15 the grit mixer through an annular passage 51 near the bottom of the mixer and leaves from a central outlet 52 near the centre of the mixer so that the output of the valves 309 has to pass through the contents of the mixer and thus any instantaneous variations in concentration of the abrasive material are smoothed out and the 20 cutting performance of the jet from the nozzle is not seriously impaired. An optional air bleed conduit 53 extends upwards from the central outlet to the top of the reservoir.

The continuous bleed provided from the outlet 226 does not seriously affect the operation of the pressure vessel 201 during 25 the filling phase. Without the continuous bleed, the pressure remaining within the vessel at the end of the discharge phase has been found to make it difficult to operate valves to facilitate the filling. When the continuous bleed is provided as in Figure 2, it has been found that the excess pressure within the vessel 201 can 30 be reduced over a period of say 30 seconds, thus allowing the flow of fluids for the emptying phase to commence without difficulty after this delay has elapsed. Alternative methods of pressure control can be used, depending on the circumstances.

CLAIMS

1. An abrasive mixture supply apparatus comprising a pressure vessel, means to supply abrasive mixture to the pressure vessel, means to apply pressure to the mixture in the pressure vessel to drive the mixture under pressure through an outlet conduit, a valve in the outlet conduit and means to flush abrasive material from said valve prior to closure of said valve.
2. Apparatus as claimed in Claim 1 comprising an abrasive mixing reservoir in said outlet conduit downstream of said abrasive material flushing means.
3. Apparatus as claimed in Claim 1 or Claim 2 comprising two said pressure vessels interconnected to enable one vessel to discharge abrasive slurry while the other is being recharged in a cyclic arrangement to provide a continuous flow of abrasive slurry from said outlet conduit, there being a said abrasive material flushing means associated with each pressure vessel.
4. Apparatus as claimed in Claim 2 and Claim 3 wherein said valves associated with said flushing means are arranged in parallel with their outlets connected to a common mixing reservoir.
5. Abrasive mixture supply apparatus substantially as hereinbefore described with reference to the accompanying drawings.